METHOD AND SYSTEM OF MANAGING AC POWER NETWORKS BASED UPON FLOW-GATE MARKET TRANSACTIONS

Technical field

This invention relates to methods of controlling electrical power transmission, more specifically, AC electrical power transmission in a frequency controlled AC power network.

Background Art

Ever since the invention of AC power technology, this and many other countries have benefited from the ability to share the use of AC electrical power across great distances. This AC power technology has proven to be of enormous value. However, the management and control of AC power networks have shown themselves to have fundamental problems. But before discussing these problems, it is important to consider some basic physical properties distinguishing AC power distribution systems from other flow based systems such as DC power, gas, water and oil transmission systems.

An AC power network is an electrical network connecting AC power generators to AC power loads on power lines controlled so that the network as a whole can be seen to function at an essentially constant frequency and uniform phase across the network. Drifts in phase are compensated by phase shifting devices to enforce the uniform phase property across the AC power network. Drifts in frequency are compensated at the generators. Such frequency variations are typically caused by variances between the loads and generated power. The effect of these compensations is to operationally provide essentially constant frequency and uniform phase throughout the AC power network. The AC power distribution frequency in the United States, Canada, Mexico and some other countries is 60 Hz and in some other countries is 50 Hz. In certain cases, the

power is distributed in a 2-phase transmission scheme. In certain other instances, the power is distributed in a 3-phase transmission scheme.

A grid as used herein will refer to an electrical power system which may comprise more than one AC power network as well as DC power lines which may transfer energy between nodes of different AC power networks or between nodes of a single AC power network.

Cities, generators and the like act as the nodes of an AC power network. A specific node may actually comprise more than one generator or load. A bus locally connects these local facilities of a node. High voltage AC transmission lines transfer power between the cities and the generators in major load centers of an AC power network. By way of example, in the United States, there's an AC power network that covers what is called the Western States Coordinating Council, which goes from British Columbia in Canada down to Northern Mexico and over to the Rocky Mountains. There's another AC power network in Texas and there's another AC power network essentially covering the rest of the United States and Canada, with the exception of a portion of Quebec. These three AC power networks are connected together by direct current lines to form the North American grid. They're not connected in AC. They are asynchronous, in that they are not synchronized either in terms of frequency or phase across the United States, Canada and northern Mexico.

Another property distinguishes AC power networks from gas, water, oil and other fluid flow distribution systems. In AC power networks, changes in power generation and loading propagate across such networks at approximately the speed of light, so that the effect of power generation and power loading on a network effects the whole network in a manner that, for practical purposes, is simultaneous.

Due to the stability of frequency and phase across an AC power network, changes in power have a super positioning effect. This insures that the power

being carried on any line in the network is essentially a linear function of the generators and loads on the network. Furthermore, if a path of lines connects two nodes, generating power at the first node carried by the path is offset by power generated at the second node, as related by the just mentioned linear function.

These AC power networks are operated within a safe range, so that the patterns of flows are fairly predictable, given the configuration of the network does not change. The North American Electric Reliability Council computes a system of a set of numbers called transfer distribution factors available on the North American Electric Reliability Council website, www.nerc.com, showing how the power is distributed across these various lines. It is a linear function of the amount injected, which changes sign when the direction of transfer changes from Node1 to Node2 into Node2 to Node1. Such functions are skew symmetric with respect to the nodes.

Consider a DC network: one can directly control the delivery of power from one point to another. This cannot be done on AC power networks. It is a characteristic of AC power networks that all lines are affected in roughly fixed proportions, the previously mentioned transfer distribution factors, by the generating and loading at specific nodes.

By way of example, when AC power is sent from Bonneville Power Authority in the state of Washington to San Francisco, some of it comes down the direct path and some of it comes down through Idaho to Arizona and back up from Southern California to Northern California. One may be limited in what can be brought from the Bonneville Power Authority to San Francisco because there's a problem with the flow coming up from Southern California to Northern California.

Consider an AC power network. There can be unlimited number of sources and loads in that network. Eventually though, the network runs out of capacity. There are certain lines or collections of lines of the network that are going to run out

ahead of others and those constrained flow elements are a big problem for the electricity industry. These lines may typically be limited either by line carrying capacity or by transformer capacity limits associated with those lines. Note that there may be more than one transformer involved and that different transformers may have differing transformer capacity limits. These constrained flow elements are called flow gates. In the last few years the importance of flow gates has begun to emerge through the actions of NERC, which has been responsible for building a model estimating flow gate impact, which can be downloaded from their web site.

A flow gate of a given AC power network will refer herein to a collection of at least one line whose total maximum safe carrying capacity will act as a congested element of the network, constraining AC power delivery between two or more nodes of that network.

All lines have maximum safe carrying capacities and thus could be considered flow gates, of a sort. However, historical congestion analysis of specific AC power networks reveals that only a small number of flow gates account for almost all congestion problems. Such flow gates will be herein referred to as significant flow gates. Note that maximum safe carrying capacity is usually defined in terms of the overall system network reliability, which includes more than just what conditions that cause line failure.

The associated AC power transfer across a given flow gate is additive due to the super positioning effects previously discussed. Thus in sending 100 megawatts along a path, the transmission may have a 10% impact on the flow gate, putting 10 megawatts on the flow gate. A second generator may have a 5% impact on that flow gate. Generating 100 megawatt at the second generator would add 5 across the flow gate.

Figure **1** depicts an exemplary AC power network based upon contemporary AC power technology as found in the prior art. The network contains 12 nodes labeled **10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110** and **120** respectively.

AC transmission line **12** runs between node **10** and node **20**. Line **14** runs between node **10** and node **40**. Line **22** runs between node **20** and node **30**. Line **32** runs between node **30** and node **40**. Line **42** runs between node **40** and node **120**. Line **44** runs between node **40** and node **60**. Line **46** runs between node **40** and node **50**. Line **52** runs between node **50** and node **110**. Line **54** runs between node **50** and node **60**. Line **56** runs between node **50** and node **70**. Line **62** runs between node **60** and node **110**. Line **64** runs between node **60** and node **70**. Line **82** runs between node **80** and node **90**. Line **92** runs between node **90** and node **120**. Line **94** runs between node **90** and node **110**. Line **96** runs between node **90** and node **100**. Line **102** runs between node **100** and node **110**. Line **112** runs between node **110** and node **120**.

Flow gate A **210** is a constraint on the network. Lines **32**, **34** and **42** are constrained by flow gate A **210** by a total maximum safe carrying capacity, in that these lines have transmission capacity limitations which are easily overloaded when this maximum safe carrying capacity is exceeded.

Flow gate B **220** is a constraint on the network. Lines **42** and **44** are constrained by flow gate B **220**. These lines are also constrained by a total maximum safe carrying capacity due to system limitations, such as their proximity at some critical junction of the system, such as a mountain pass.

Flow gate C **230** is a constraint on the network. Lines **52** and **62** are constrained by flow gate C **230** to a total maximum safe carrying capacity.

Figure **2** depicts a list of associated AC power transfer functions for each flow gate of a collection of flow gates for each of the buses of the various nodes of the exemplary AC power network of Figure **1** as disclosed in the prior art.

Bus **1** locally connects all facilities of Node **10**. Bus **2** locally connects all facilities of Node **20**. Bus **3** locally connects all facilities of Node **30**. Bus **4** locally connects all facilities of Node **40**. Bus **5** locally connects all facilities of Node **50**. Bus **6** locally connects all facilities of Node **60**.

Bus **7** locally connects all facilities of Node **70**. Bus **8** locally connects all facilities of Node **80**. Bus **9** locally connects all facilities of Node **90**. Bus **10** locally connects all facilities of Node **100**. Bus **11** locally connects all facilities of Node **110**. Bus **12** locally connects all facilities of Node **120**.

Note that the facilities at these nodes, connected by the associated bus, often varying greatly in terms of generation capacity as well as loading capacity. By way of example, a city often consumes far more AC power than it generates. Another example, a node for a major hydroelectric dam such as Grand Coulee Dam would tend to generate far more AC power than it consumed.

Note that the associated AC power transfer functions for the various buses are all fractions of 1, since the most power that could be transferred is the amount of power at the generation node. Note further that some of these AC power transfer functions are negative. Bus **11** has strictly zeroes for its power transfer function. It is essentially acting as a reference node for calculating the associated functions. Note that identification of the reference node is done for convenience. Any bus can serve as the reference node.

Consider how AC power transfers are managed today. In the United States, the Federal Energy Regulatory Commission (FERC) has called for the development of Regional Transmission Organizations (RTOs) to better coordinate markets and foster reliability (in FERC Docket No. RM99-2-000 issued May 13, 1999). The electric power industry has a long history of using centralized dispatch to manage generation, as opposed to open markets. Centralized dispatch was suited to an industry consisting of vertically integrated monopolies. The traditional approach to RTO design so far has been to retain as much of this

centralized control as possible, while opening access to competitive wholesale and retail participants. The result has been volatile prices, settlement disputes, and difficulties matching supply and demand on a real-time basis. The basic problem is that centralized dispatch does not work well where participants do not have common ownership or objectives.

Today, transmission rights are further considered and negotiated in terms of point-to-point transfers within the network using a system known as contract paths. This contract path system of scheduling power transmission reserves transmission rights along a particular, direct path through the AC power network. This is done by purchasing transmission rights from each of the transmission line owners for each of the lines making up the direct path.

Such thinking is contrary to the previously discussed physics of these AC power networks, because changes in power generation or load at any node have an essentially linear effect on all transmission lines in the network, and consequently impact all flow gates within that network to some extent. It often occurs that some constraint, occurring across a significant flow gate off that direct path, actually limits the transmission capability on the direct path.

The contract path system maintains the fiction that AC power can be directed to follow a path through the network chosen as one might with natural gas. By changing the valves, one can mythically direct AC power a particular way through the AC power network. The contract path system was put in place because it was thought conceptually easier since one only had to make reservations along the single path. The fundamental problem with the contract path approach is that the contract path arrangement for transmission does not accord with the way the power actually flows in an AC power network.

Today's contract path system is based upon a first-come, first-served priority scheme. What is bought has very limited resale capability. By way of example, consider three nodes A, B and C of an AC power network. Suppose one bought

power transmission from A to B and bought transmission from B to C. Using the contract path approach, this does not necessarily mean one owns power transmission from A to C, because contract paths are not additive. Owning power transmission from A to B and from B to C would not necessarily entitle power transmission from A to C. To transport from A to C, one might have to purchase specific transmission rights from A to C. This is because of regulatory rules often reflecting some flow gate constraint which would not be met in the two separate paths which would be triggered in the combined path. So in the contract path based market, which is the traditional market, once you have purchased the transmission from A to B, it's only value is often for moving energy from A to B. This is a common experience when all three nodes are in the same control area.

It is actually worse than indicated. There are numerous times and places when owning rights from A to C does not insure that anything can be delivered from A to C, even without critical events in the network. The grid reliability operators often cut transmission due to congestion, which may not even be on the contract path. Today, there are several ad hoc approaches to limiting flow on one path because of the impact on another path. The central operator acts, because some flow gate will otherwise overflow.

Another alternative approach to the contract path system is to take all of these generator cost curves, and the buyer preference functions, into a mathematical optimization program, and figure out the optimal flow. This alternative approach has significant disadvantages. In a commercial market, getting people to reveal all their costs is quite difficult. Most people are very reluctant to do that. Further, such costs frequently change. The buyers have to reveal their preferences, which is a tremendous informational burden. It is also extremely unlikely that they could or would do it. Even if they did, collecting all this information is a tremendous burden on the central operator.

Such an alternative approach requires two-way communication among all the players, with all these generators, loads, transmission devices and systems to control over a wide region. It has proven impossible to provide the requisite level of reliable communication and direct control systems. Besides, people are unwilling to turn over control of their lives to a central operator, even if they are willing to divulge their preferences and costs.

A similar approach in industry is a power pool called PJM, for Pennsylvania, New Jersey and Maryland, who have developed a system called locational marginal pricing. It is a central dispatched methodology. However, a local flow model is buried within it. It supports some centralized management of generators and such in order to get a consistent solution that is based upon the power distribution matrix.

This approach suffers from at least the same problems facing any other centralized control scheme. There is a very limited amount of detailed information such a system can acquire, or use, to optimize AC power transfers. The power users are again blind to their options. The players cannot determine what works best for them. The central operator dictates such things to them. It is difficult to imagine that such a situation could be optimal. Worse yet, no one knows what the price of energy will be until long after it has been consumed! While there are some hedging mechanisms which have been developed, this doesn't change the fact that users are consuming power at an unknown price at the time of consumption.

NERC has developed a methodology addressing flow gates to some extent. This is discussed in a document entitled "Discussion Paper on Aligning Transmission Reservations and Energy Schedules to Actual Flows", distributed in November, 1998 by the NERC Transaction Reservation and Scheduling Self-Directed Work Team. This team proposed an electrical power industry shift to a system of reserving and scheduling transmission based on actual use of

congested flow gates, which they called the FLOWBAT method. Their proposal suffers from a serious omission, it does not address the issue of allocating flow gate capacity when demand exceeds supply. By their silence on this issue, it appears that they would continue the current practice of first-come, first-served allocation. The flaws discussed above for centralized planning continue to be relevant in this approach.

NERC has also sponsored the General Agreement on Parallel Paths Experiment (GAPP). GAPP is a system whereby one transmission provider compensates a second transmission provider for the parallel power flows occurring on a second transmission provider's system caused by transactions authorized by the first transmission provider. GAPP relies on distribution functions, in this case called Transaction Participation Functions (TPFs). These distribution functions refer to transmission paths rather than flow gates. GAPP attempts to align compensation paid by transmission users with actual power flows. However, GAPP is strictly an after-the-fact settlement system. It alters the current contract path scheme only to redistribute the revenue. It does not attempt to allocate scarce transmission capacity.

Notice that none of the prior contracting methods provide any incentive for pro-active congestion relief by the players even though opportunities to resolve congestion problems often exist. Every prior approach is based upon a central operator making unilateral actions. There is no opportunity for collective problem solving by the players before transmission occurs.

To summarize, what is needed is an AC power transmission market system complying with the physics of AC power networks. Further, since transmission rights are predominantly constrained by significant flow gates, what is needed should account for the effect on the significant flow gates for each contracted transmission.

What is further needed is a method and mechanism by which such transmission rights across significant flow gates can be traded in a timely, reliable and efficient manner which automatically guarantee correct operation of the AC power network.

Disclosure

Certain embodiments fulfill at least the requirements and needs discussed with regards to the prior art.

Certain embodiments include a method for contracting AC power transfer on an AC power network with a flow gate collection containing at least one flow gate. The method comprises contracting an AC power transfer on the AC power network, further comprising contracting an associated AC power transfer on each of the flow gates of the flow gate collection. Such a method automatically insures that the associated flow gate AC power transfer has been contracted for each flow gate of the flow gate collection.

Certain further embodiments of contracting an AC power transfer include contracting the AC power transfer to take place over a time interval. Contracting the associated AC power transfer on each flow gate of the flow gate collection further includes contracting the associated AC power transfer on each flow gate of the flow gate collection to take place at least over the time interval. Such embodiments advantageously insure that the associated AC power transfer is contracted for each flow gate of the flow gate collection over the time interval.

Certain further embodiments include contracting an AC power transfer collection of at least two AC power transfers on an AC power network. This further comprises contracting a sum of the associated AC power transfers for each of the AC power transfers of the AC power transfer collection on each of the flow gates of the flow gate collection. Such a method automatically insures that the associated flow gate AC power transfer has been contracted for each flow gate

of the flow gate collection, given the collection of AC power transfers being contracted.

Certain embodiments take into account that each flow gate of the flow gate collection has an associated maximum safe carrying capacity. Contracting the sum of associated AC power transfers on each flow gate comprises the sum of the associated AC power transfers for each AC power transfer of the AC power transfer collection satisfying the associated maximum safe carrying capacity on each flow gate of the flow gate collection. This automatically insures that the associated flow gate AC power transfer for the collection of AC power transfers satisfies the maximum safe carrying capacity of each flow gate.

Each AC power transfer of the AC power transfer collection has an associated amount of energy from an associated first node of the AC power network to a second node of the AC power network. Certain embodiments include contracting an amount of energy of the associated AC power transfer on each of the flow gates of the flow gate collection as essentially an associated linear, skew-symmetric function of the associated amount of energy from the associated first node to the second node. Such embodiments are further advantageous in complying with the observed physical characteristics of AC power networks and flow gates on such AC power networks. Additionally, this physical characteristic of AC power transfer can be used in trading to alter the AC power transfer collection so that it no longer exceeding the maximum safe carrying capacity on any of the flow gates.

Note that in certain further embodiments, enabling the first party to further contract to sell the first party owned AC power transfer trading rights further enabling the first party to further contract to sell the associated AC power transfer for a single flow gate, as well as, for all the flow gates. Such embodiments advantageously provide a fluidity for market forces to move toward optimal operating solutions based upon the internal needs and goals of the market players which cannot be attained by centralized control systems.

In certain embodiments, the first party may be a human being. In certain further embodiments, the first party may be a corporate entity. In certain further embodiments, the first party may be an agent authorized to represent the first party. In certain further embodiments, the agent may be a software agent executing on a computer. These embodiments provide the users and suppliers of AC energy to trade AC power transfer rights in terms of flow gates, removing the necessity of a centralized control system dominating the operation of such AC power networks.

In certain embodiments, a computing system comprised of at least one computer with coupled computer readable memory provides for the execution of a program operating system containing program code segments supporting the operations of the above discussed embodiments. Such embodiments provide an execution environment advantageously supporting these operations.

In certain further embodiments, the computing system further includes a client computer collection, a server system and a network. The client computer collection contains at least one client computer operated by a client. The server system contains at least one server computer. The network couples the client computer of the client computer collection and coupling at least a first of the server computers of the server system. Contracting the AC power transfer on the AC power network further comprises identifying a first of the clients operating a first of the client computers as the first party. Such embodiments advantageously provide clients operated computers communicating in a secure fashion with the server system.

In certain further embodiments, a first client user operating the first client computer as the first party residing on the computer readable memory coupled to the first client computer includes the following operations: receiving stimulus from the first user, communicating via the network with the first server computer and displaying an interactive status. This advantageously provides basic support for

a user interface to the contracting mechanism for AC power transfers on the AC power network.

In certain further embodiments, contracting the AC power transfer on the AC power network further comprises communicating via the network with the first client computer. This advantageously provides for the reception of the client computer communication as part of the contracting process.

In certain further embodiments, contracting for AC power transfer further includes operating a virtual trading floor containing a market for trading AC power transfer for each of the flow gates of the flow gate collection. In certain further embodiments operating the virtual trading floor for AC power transfer further include transforming the received server delivery stream into an order collection and contracting to create an agreed contract based upon a first bid order and a first ask order. These embodiments advantageously support a bid and ask order system of trading.

In certain further embodiments, the virtual trading floor includes at least one market interval associated with each flow gate of the flow gate collection. This advantageously supports trading in each flow gate AC power transfer in a fashion that directly maps to the physical behavior of the AC power network and its flow gates.

In certain further embodiments, the server system is further comprised of a reliable server collection of server computers performing a reliable distributed system with a process group collection of at least one process group. Each of the server computers is accessibly coupled with a computer memory, of the reliable server system. The program operating system includes program code segments implementing at least one of the process groups of the collection of process groups. Such embodiments advantageously support the above process in a reliable, fault tolerant manner.

These and other advantages of the present invention will become apparent upon reading the following detailed descriptions and studying the various figures of the drawings.

Brief Description of the Drawings

Figure **1** depicts an exemplary AC power network based upon contemporary AC power technology as found in the prior art;

Figure **2** depicts a list of associated AC power transfer functions for each flow gate of a collection of flow gates for each of the buses of the various nodes of the exemplary AC power network of Figure **1** as disclosed in the prior art;

Figure **3** depicts contracting an AC power transfer on an AC power network in accordance with certain embodiments;

Figure **4** depicts detail operation **1004** of Figure **3** contracting an associated AC power transfer on each of the flow gates of the flow gate collection in accordance with certain embodiments;

Figure **5** depicts detail of operation **1004** of Figure **3** when contracting for AC power transfer to take place over a first time interval in accordance with certain embodiments;

Figure **6** depicts detail of operation **1022** of Figure **4** contracting the associated AC power transfer on each of the flow gates of the flow gate collection to take place over at least the first time interval in accordance with certain embodiments;

Figure **7** depicts a flowchart contracting an AC power transfer collection of at least two AC power transfers on an AC power network in accordance with certain embodiments;

Figure **8** depicts a detail flowchart of operation **1084** of Figure **7** performing contracting a sum of the associated AC power transfer for each of the AC power transfers of the AC power transfer collection on each of the flow gates of the flow gate collection in accordance with certain embodiments;

Figure **9** depicts a detail flowchart of operation **1102** of Figure **8** performing the sum of the associated AC power transfer for each AC power transfer of the AC power transfer collection satisfying the associated maximum safe carrying capacity on each flow gate of the flow gate collection in accordance with certain embodiments;

Figure **10** depicts a detail flowchart of operation **1102** of Figure **8** performing contracting each sum of associated AC power transfer for each AC power transfer of the AC power transfer collection to take place at least over the first time interval in accordance with certain embodiments;

Figure **11** depicts a detail flowchart of operation **1102** of Figure **8** performing contracting an amount of energy of the associated AC power transfer on each of the flow gates of the flow gate collection as essentially an associated linear, skew-symmetric function of the associated amount of energy from the associated first node to the associated second node in accordance with certain embodiments;

Figure **12** depicts a detail of operation **1004** of Figure **3** contracting for the AC power transfer on the AC power network to create an agreed contract by a first party to own AC power transfer trading rights and enabling those rights to be further contracted in accordance with certain embodiments;

Figure **13** depicts a flowchart scheduling the AC power transfer on the AC power network with the flow gate collection in accordance with certain embodiments;

Figure **14** depicts a detail flowchart of operation **1186** of Figure **12** performing enabling the first party to further contract to sell the first party owned AC power

transfer trading rights before scheduling the AC power transfer for the agreed contract;

Figure **15** depicts a detail flowchart of operation **1210** of Figure **13** performing scheduling of the AC power transfer for the agreed contract occurring before the first time interval;

Figure **16** depicts a detail flowchart of operation **1214** of Figure **13** performing determining whether the associated AC power transfer of the flow gate of the flow gate collection satisfies the associated maximum safe carrying capacity of the flow gate for each of the flow gates of the flow gate collection over the first time interval;

Figure **17** depicts a detail flowchart of operation **1218** of Figure **13** performing approving the AC power transfer over the first time interval whenever the associated AC power transfer of the flow gate satisfies the maximum safe carrying capacity for each the flow gates of the flow gate collection over the first time interval;

Figure **18** depicts a flowchart performing contracting for an AC power transfer collection of at least one AC power transfer to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow gates of the flow gate collection;

Figure **19** depicts a detail flowchart of operation **1314** of Figure **18** performing contracting for a sum of associated AC power transfers for all AC power transfers of the AC power transfer collection to create a contract for an associated AC power transfer for the collection of AC power transfers for each of the flow gates of the flow gate collection;

Figure **20** depicts a detail flowchart of operation **1332** of Figure **19** performing calculating the associated AC power transfer on the flow gate of the AC power transfer as an amount of energy which is an essentially linear, skew-symmetric

associated function of the amount of energy of the AC power transfer from the associated first node of the AC power transfer to the associated second node of the AC power transfer of each of the flow gates of the flow gate collection;

Figure **21** depicts a detail flowchart of operation **1186** of Figure **12** performing enabling the first party to further contract to sell the first party owned AC power transfer trading rights for the associated AC power transfer for a first of the flow gates of the flow gate collection;

Figure **22** depicts a detail flowchart of operation **1186** of Figure **12** performing enabling the first party to further contract to sell the first party owned AC power transfer trading rights for the associated AC power transfer for each of the flow gates of the flow gate collection;

Figure **23** depicts a simplified system block of a computing system **2000** supporting contracting AC power transfer on an AC power network with a flow gate collection in accordance with certain embodiments;

Figure **24** depicts a refinement of computing system **2000** as a system diagram in Figure **23** in accordance with certain further embodiments;

Figure **25A** depicts a detail flowchart of operation **1000** of Figure **3** performing identifying a first of the clients operating a first of the client computers as the first party;

Figure **25B** depicts a flowchart of the first client user operating the first client computer as the first party;

Figure **26** depicts a detail flowchart of operation **1434** of Figure **25B** performing operations related to first client stimulus, response and network communication with a first server computer of the server system;

Figure **27** depicts a detail flowchart of operation **1004** of Figure **3** performing communicating via the network with the first client computer to create a received server delivery stream;

Figure **28** depicts a virtual trading floor **3000**, containing validated orders and market intervals with associated market states in accordance with certain embodiments;

Figure **29** depicts a detail flowchart of operation **1004** of Figure **3** performing supporting operating a virtual trading floor containing a market interval for trading AC power transfer for each of the flow gates of the flow gate collection;

Figure **30** depicts a detail flowchart of operation **1512** of Figure **29** performing collecting orders and creating contracts in accordance with certain embodiments;

Figure **31** depicts a detail flowchart of operation **1004** of Figure **3** contracting AC power transfer based upon a first bid type order of the validated orders of the validated order collection and a first ask type order of the validated orders of the validated order collection;

Figure **32** depicts a detail flowchart of operation **1182** of Figure **12** performing contracting for the AC power transfer on the AC power network to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow gates of the flow gate collection based upon a first bid type order of the validated orders of the validated order collection and a first ask type order of the validated orders of the validated order collection;

Figure **33A** depicts a flowchart of operations as previously described which collectively are included in the process groups performed on the reliable server system in accordance with certain embodiments;

Figure **33B** depicts a method of controlling the interaction between a client **2190** and a virtual trading floor comprising maintaining a session component **3300**, participant component **3320** and market segment **3340** in accordance with certain embodiments;

Figure **33C** depicts a refinement of computing system **2000** as a system diagram in Figure **24** in accordance with certain further embodiments;

Figure **34** depicts a view of a certified client user interface operating on a client computer showing an ordering screen with hourly time interval based market intervals for a specific energy market in accordance with certain embodiments;

Figure **35** depicts a view of a certified client user interface operating on a client computer showing an ordering screen for daily on-peak time interval based market intervals for a specific energy market in accordance with certain embodiments; and

Figure **36** depicts a view of a certified client user interface operating on a client computer showing an ordering screen for hourly time interval based market intervals for a specific flow gate market in accordance with certain embodiments.

Detailed Description

Figures **1** depicts an exemplary network constructed of prior art AC power transmission, distribution, generation and loading equipment showing nodes, lines and a collection of flow gates. Figure **2** depicts a list of associated AC power transfer functions for each flow gate of a collection of flow gates for each of the buses of the various nodes of the exemplary AC power network of Figure **1** as disclosed in the prior art.

Figure **3** depicts contracting an AC power transfer **1000** on an AC power network in accordance with certain embodiments.

In certain embodiments, operation **1000** starts the operations of this flowchart. Arrow **1002** directs the flow of execution from operation **1000** to operation **1004**. Operation **1004** performs contracting an AC power transfer on the AC power network. Arrow **1006** directs execution from operation **1004** to operation **1008**. Operation **1008** terminates the operations of this flowchart.

In certain embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

As used herein, the term computer refers to devices including instruction set computers, inferential computers, and analog computers, as well as aggregates of these basic kinds of computers. A computer will also refer to informational appliances incorporating one or more computers in their construction. Such informational appliances may be physically distinct units, or they may be tangibly integrated into other devices, or they may be tangibly integrated into the physically mobile neighborhood of one or more human beings.

As used herein, certain computers, including instruction-processing computers and inferential computers include coupled computer readable memory to hold what will be termed herein as instructions. Instructions as used herein with regard to instruction set computers will refer to information controlling state transition of such instruction computers. Based upon the current instruction or collection of instructions being executed and the internal state of the instruction-processing computer will determine the future state of the instruction-processing computer. Note that these instructions may either be directly executed by the instruction-processing computer or may be interpretively executed by the instruction-processing computer.

Instructions as used herein with regard to inferential computers will refer to information presented to the inferential computer used to infer the future state of

the computer based upon an inference base of the inferential computer directed by the presented instruction. Such an inference base may reside internal to the inferential computer in certain cases, or reside in coupled computer accessible memory, which may be both read and written by the inferential computer. Note that inferential computers include but are not limited to machines executing various forms of Horn clause predicates as well as constraint rules, pattern recognition templates, fractal pattern templates and fuzzy logic predicate structural elements.

Analog computers as used herein include but are not limited to devices directly coupling to analog circuitry. Such analog circuitry as used herein includes, but is not limited to, radio frequency IF stages, opto-electronic interfaces such as lasers embedded in fiber optic communications systems, audio and video pattern recognition circuitry, audio and video output devices. Analog computers as used herein include but are not limited to acoustic interfaces to humans, audio and visual identification portals to the contracting of AC power transfer regarding flow gates, encoding and decoding mechanisms used in long distance communication and interfaces to recording devices of agreed contracts.

A program code segment as used herein refers to instructions in a form executable or inferentially directing for the computer coupled to the computer readable memory in which the program code segment resides. Note that in certain embodiments, program code segments may be native executable instructions of an instruction-processing computer. In certain other embodiments, program code segments may be interpretively executed instructions of an instruction-processing computer.

Figure **4** depicts detail operation **1004** of Figure **3** contracting an associated AC power transfer on each of the flow gates of the flow gate collection in accordance with certain embodiments.

Arrow **1020** directs the flow of execution from starting operation **1004** to operation **1022**. Operation **1022** performs contracting an associated AC power transfer on each of the flow gates of the flow gate collection. Arrow **1024** directs the flow of execution from starting operation **1020** to operation **1026**. Operation **1026** terminates the operations of this flowchart.

In certain embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting an associated AC power transfer on each of the flow gates of the flow gate collection in accordance with certain embodiments.

In certain further embodiments, contracting for an AC power transfer includes other substantial terms besides contracting for the associated AC power transfer for each flow gate of the flow gate collection.

In certain embodiments, contracting for an AC power transfer includes contracting for the associated AC power transfers on each flow gate of the flow gate collection in a written contracting mechanism. Such written mechanisms operate with physically proximate parties in certain further embodiments. In certain alternative further embodiments, physically disparate parties may operate such written mechanisms.

In certain other embodiments, contracting for an AC power transfer includes contracting for the associated AC power transfers on each of the flow gates of a flow gate collection in a body-signal based contracting mechanism. In certain further embodiments, contracting for an AC power transfer includes contracting for associated AC power transfers on each flow gate of the flow gate collection in a verbal contracting mechanism.

In certain other further embodiments, contracting for an AC power transfer includes contracting for the associated AC power transfers on each of the flow gates of a flow gate collection in a sign language-based contracting mechanism.

In certain still further embodiments, the sign language-based contracting mechanism may further include additional attributes associated with the body. Such attributes include but are not limited to notes held in the hand, or worn on the body, as well as images triggered on a heads-up display via previous actions of one or more parties.

In certain other embodiments, contracting for an AC power transfer includes contracting for associated AC power transfers on each flow gate of the flow gate collection in a contracting mechanism involving computers. In certain other embodiments, contracting for an AC power transfer includes contracting for the associated AC power transfers on each of the flow gates of a flow gate collection in a contracting mechanism involving computers communicating across a network with other computers.

Note that contracting AC power transfers does not necessitate specification of a time interval for the AC power transfer. A contracting entity investing in an AC power generation facility may receive a perpetual right to some portion of the power generated by that facility. Similarly, a contracting entity investing in an AC power transmission line and/or equipment may receive a perpetual right to some AC power transmission over that component of the AC power network for an indefinitely long period of time.

Figure **5** depicts detail of operation **1004** of Figure **3** when contracting for AC power transfer to take place over a first time interval in accordance with certain embodiments.

Arrow **1040** directs the flow of execution from starting operation **1004** to operation **1042**. Operation **1042** performs contracting for AC power transfer on the AC power network to take place over a first time interval. Arrow **1044** directs execution from operation **1042** to operation **1046**. Operation **1046** terminates the operations of this flowchart.

In certain embodiments, contracting AC power transfers entails such AC power transfers taking place over a first time interval. A simple time interval as used herein possesses a starting time and an ending time and designates the progression of time from the starting time until the ending time. This progression of time is constructed such that for a first simple time interval having an ending time coinciding with the starting time of a second simple time interval, the first time simple interval does not overlap with the second simple time interval. As used herein, a time interval contains at least one non-overlapping simple time interval.

In certain embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

In certain embodiments, simple time intervals contain their starting time in their progression of time and do not containing their ending time in their progression of time. In certain alternative embodiments, simple time intervals do not contain their starting time in their progression of time but do contain their ending time in their progression of time.

Figure **6** depicts detail of operation **1022** of Figure **4** contracting the associated AC power transfer on each of the flow gates of the flow gate collection to take place over at least the first time interval in accordance with certain embodiments.

Arrow **1060** directs the flow of execution from starting operation **1022** to operation **1062**. Operation **1062** performs contracting the associated AC power transfer on each of the flow gates of the flow gate collection to take place over at least the first time interval. Arrow **1064** directs execution from operation **1062** to operation **1066**. Operation **1066** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one

computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **7** depicts a flowchart contracting an AC power transfer collection of at least two AC power transfers on an AC power network in accordance with certain embodiments.

Operation **1080** starts the operations of this flowchart. Arrow **1082** directs the flow of execution from operation **1080** to operation **1084**. Operation **1084** performs contracting an AC power transfer collection of at least two AC power transfers on an AC power network. Arrow **1086** directs execution from operation **1084** to operation **1088**. Operation **1088** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **8** depicts a detail flowchart of operation **1084** of Figure **7** performing contracting a sum of the associated AC power transfer for each of the AC power transfers of the AC power transfer collection on each of the flow gates of the flow gate collection in accordance with certain embodiments.

Arrow **1100** directs the flow of execution from starting operation **1084** to operation **1102**. Operation **1102** performs contracting a sum of the associated AC power transfer for each of the AC power transfers of the AC power transfer collection on each of the flow gates of the flow gate collection. Arrow **1104** directs execution from operation **1102** to operation **1106**. Operation **1106** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one

computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Note that in certain embodiments, each flow gate of the flow gate collection has an associated maximum safe carrying capacity.

Figure **9** depicts a detail flowchart of operation **1102** of Figure **8** performing the sum of the associated AC power transfer for each AC power transfer of the AC power transfer collection satisfying the associated maximum safe carrying capacity on each flow gate of the flow gate collection in accordance with certain embodiments.

Arrow **1120** directs the flow of execution from starting operation **1102** to operation **1122**. Operation **1122** performs the sum of the associated AC power transfer for each AC power transfer of the AC power transfer collection satisfying the associated maximum safe carrying capacity on each flow gate of the flow gate collection. Arrow **1124** directs execution from operation **1122** to operation **1126**. Operation **1126** terminates the operations of this flowchart.

In certain embodiments, satisfying the maximum safe carrying capacity is automatically performed based upon an initial auction of AC power transfer trading rights by each flow gate facility owner. In certain further embodiments, satisfying the maximum safe carrying capacity is automatically performed by further contracting countervailing AC power transfers to insure that the sum of associated AC power transfers on each flow gate satisfies the maximum safe carrying capacity of the flow gate.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Note that in certain embodiments, each of the AC power transfers of the AC power transfer collection is to take place over a first time interval.

Figure **10** depicts a detail flowchart of operation **1102** of Figure **8** performing contracting each sum of associated AC power transfer for each AC power transfer of the AC power transfer collection to take place at least over the first time interval in accordance with certain embodiments.

Arrow **1140** directs the flow of execution from starting operation **1102** to operation **1142**. Operation **1142** performs contracting each of the sum of the associated AC power transfers for each of the AC power transfers of the AC power transfer collection to take place at least over the first time interval. Arrow **1144** directs execution from operation **1142** to operation **1146**. Operation **1146** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

In certain embodiments, each of the AC power transfers of the AC power transfer collection has an associated amount of energy from an associated first node of the AC power network to a second node of the AC power network.

Figure **11** depicts a detail flowchart of operation **1102** of Figure **8** performing contracting an amount of energy of the associated AC power transfer on each of the flow gates of the flow gate collection as essentially an associated linear, skew-symmetric function of the associated amount of energy from the associated first node to the associated second node in accordance with certain embodiments.

Arrow **1160** directs the flow of execution from starting operation **1102** to operation **1162**. Operation **1162** performs contracting an amount of energy of

the associated AC power transfer on each of the flow gates of the flow gate collection as essentially an associated linear, skew-symmetric function of the associated amount of energy from the associated first node to the associated second node. Arrow **1164** directs execution from operation **1162** to operation **1166**. Operation **1166** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Note that in certain embodiments, each flow gate of a flow gate collection of an AC power network may be a significant flow gate. In certain embodiments, each significant flow gate of an AC power network is a member of the flow gate collection. Note that in certain embodiments, a flow gate may be included in an AC power network flow gate collection which is not a significant flow gate. Situations where this may occur include but are not limited to situations where a portion of the transmission lines or support equipment, such as transformers, may be damaged and be temporarily disconnected from the AC power network. Additionally, some transmission line may be vital to a regionally determined priority, and may, for regional operating policy reasons, be included in the flow gate collection while not being strictly a significant flow gate. Further, additionally, a flow gate collection may be determined by regional operating policy, which may utilize different criteria than those described herein, but which provide the automatic handling of congestion through the trading of transmission rights for a collection of flow gates.

Figure **12** depicts a detail of operation **1004** of Figure **3** contracting for the AC power transfer on the AC power network to create an agreed contract by a first party to own AC power transfer trading rights and enabling those rights to be further contracted in accordance with certain embodiments.

Arrow **1180** directs the flow of execution from starting operation **1004** to operation **1182**. Operation **1182** performs contracting for the AC power transfer on the AC power network to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow gates of the flow gate collection. Arrow **1184** directs execution from operation **1182** to operation **1186**. Operation **1186** performs enabling the first party to further contract to sell the first party owned AC power transfer trading rights. Arrow **1188** directs execution from operation **1186** to operation **1190**. Operation **1190** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by at least one program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection. Note that in certain embodiments, these operations may be performed by distinct program code segments involving distinct execution or inferential language structures.

In certain embodiments, each of the flow gates of the flow gate collection has an associated maximum safe carrying capacity.

Figure **13** depicts a flowchart scheduling the AC power transfer on the AC power network with the flow gate collection in accordance with certain embodiments.

Operation **1210** starts the operations of this flowchart. Arrow **1212** directs the flow of execution from operation **1210** to operation **1214**. Operation **1214** performs determining whether the associated AC power transfer of the flow gate of the flow gate collection satisfies the associated maximum safe carrying capacity of the flow gate for each of the flow gates of the flow gate collection. Arrow **1216** directs execution from operation **1214** to operation **1218**. Operation **1218** performs approving the AC power transfer whenever the associated AC power transfer of the flow gate satisfies the maximum safe carrying capacity for each of the flow gates of the flow gate collection. Arrow **1220** directs execution

from operation **1218** to operation **1222**. Operation **1222** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by at least one program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection. Note that in certain embodiments, these operations may be performed by distinct program code segments involving distinct execution or inferential language structures.

Figure **14** depicts a detail flowchart of operation **1186** of Figure **12** performing enabling the first party to further contract to sell the first party owned AC power transfer trading rights before scheduling the AC power transfer for the agreed contract.

Arrow **1230** directs the flow of execution from starting operation **1186** to operation **1232**. Operation **1232** performs enabling the first party to further contract to sell the first party owned AC power transfer trading rights before scheduling the AC power transfer for the agreed contract. Arrow **1234** directs execution from operation **1232** to operation **1236**. Operation **1236** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

In certain embodiments, the agreed contract by the first party to own the AC power transfer trading rights with the associated AC power transfers on a first of the flow gates of the flow gate collection is to take place over a first time interval.

Figure **15** depicts a detail flowchart of operation **1210** of Figure **13** performing scheduling of the AC power transfer for the agreed contract occurring before the first time interval.

Arrow **1250** directs the flow of execution from starting operation **1210** to operation **1252**. Operation **1252** performs scheduling the AC power transfer for the agreed contract occurring before the first time interval. Arrow **1254** directs execution from operation **1252** to operation **1256**. Operation **1256** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **16** depicts a detail flowchart of operation **1214** of Figure **13** performing determining whether the associated AC power transfer of the flow gate of the flow gate collection satisfies the associated maximum safe carrying capacity of the flow gate for each of the flow gates of the flow gate collection over the first time interval.

Arrow **1270** directs the flow of execution from starting operation **1214** to operation **1272**. Operation **1272** performs determining whether the associated AC power transfer of the flow gate of the flow gate collection satisfies the associated maximum safe carrying capacity of the flow gate for each of the flow gates of the flow gate collection over the first time interval. Arrow **1274** directs execution from operation **1272** to operation **1276**. Operation **1276** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection. In certain further embodiments, these

operations are embedded in a time triggered program code segment which performs operation **1210**, scheduling the AC power transfer before the first time interval.

Figure **17** depicts a detail flowchart of operation **1218** of Figure **13** performing approving the AC power transfer over the first time interval whenever the associated AC power transfer of the flow gate satisfies the maximum safe carrying capacity for each the flow gates of the flow gate collection over the first time interval.

Arrow **1290** directs the flow of execution from starting operation **1218** to operation **1292**. Operation **1292** performs approving the AC power transfer over the first time interval whenever the associated AC power transfer of the flow gate satisfies the maximum safe carrying capacity for each the flow gates of the flow gate collection over the first time interval. Arrow **1294** directs execution from operation **1292** to operation **1296**. Operation **1296** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **18** depicts a flowchart performing contracting for an AC power transfer collection of at least one AC power transfer to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow gates of the flow gate collection.

Operation **1310** starts the operations of this flowchart. Arrow **1312** directs the flow of execution from operation **1310** to operation **1314**. Operation **1314** performs contracting for an AC power transfer collection of at least one AC power transfer to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow

gates of the flow gate collection. Arrow **1316** directs execution from operation **1314** to operation **1318**. Operation **1318** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **19** depicts a detail flowchart of operation **1314** of Figure **18** performing contracting for a sum of associated AC power transfers for all AC power transfers of the AC power transfer collection to create a contract for an associated AC power transfer for the collection of AC power transfers for each of the flow gates of the flow gate collection.

Arrow **1330** directs the flow of execution from starting operation **1314** to operation **1332**. Operation **1332** performs contracting for a sum of associated AC power transfers for all AC power transfers of the AC power transfer collection to create a contract for an associated AC power transfer for the collection of AC power transfers for each of the flow gates of the flow gate collection. Arrow **1334** directs execution from operation **1332** to operation **1336**. Operation **1336** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

In certain embodiments, each of the AC power transfers of the AC power transfer collection has an associated amount of energy from an associated first node of the AC power network to the second node of the AC power network.

Figure **20** depicts a detail flowchart of operation **1332** of Figure **19** performing calculating the associated AC power transfer on the flow gate of the AC power transfer as an amount of energy which is an essentially linear, skew-symmetric associated function of the amount of energy of the AC power transfer from the associated first node of the AC power transfer to the associated second node of the AC power transfer of each of the flow gates of the flow gate collection.

Arrow **1350** directs the flow of execution from starting operation **1332** to operation **1352**. Operation **1352** performs calculating the associated AC power transfer on the flow gate of the AC power transfer as an amount of energy which is an essentially linear, skew-symmetric associated function of the amount of energy of the AC power transfer from the associated first node of the AC power transfer to the associated second node of the AC power transfer of each of the flow gates of the flow gate collection. Arrow **1354** directs execution from operation **1352** to operation **1356**. Operation **1356** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **21** depicts a detail flowchart of operation **1186** of Figure **12** performing enabling the first party to further contract to sell the first party owned AC power transfer trading rights for the associated AC power transfer for a first of the flow gates of the flow gate collection.

Arrow **1370** directs the flow of execution from starting operation **1186** to operation **1372**. Operation **1372** performs enabling the first party to further contract to sell the first party owned AC power transfer trading rights for the associated AC power transfer for a first of the flow gates of the flow gate

collection. Arrow 1[redacted] directs execution from operation 1[redacted] to operation **1376**. Operation **1376** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

Figure **22** depicts a detail flowchart of operation **1186** of Figure **12** performing enabling the first party to further contract to sell the first party owned AC power transfer trading rights for the associated AC power transfer for each of the flow gates of the flow gate collection.

Arrow **1390** directs the flow of execution from starting operation **1186** to operation **1392**. Operation **1392** performs enabling the first party to further contract to sell the first party owned AC power transfer trading rights for the associated AC power transfer for each of the flow gates of the flow gate collection. Arrow **1394** directs execution from operation **1392** to operation **1396**. Operation **1396** terminates the operations of this flowchart.

In certain other embodiments, these operations are supported by a program code segment residing in a coupled computer readable memory on at least one computer in a computing system for contracting AC power transfers on an AC power network with a flow gate collection.

In certain embodiments, the first party may be a human being. In certain other embodiments, the first party may be a corporate entity. In certain further embodiments, the corporate entity may be a corporation. In certain other further embodiments, the corporate entity may be a form of partnership.

In certain other embodiments, the first party is represented by an agent authorized by the first party to act on behalf of the first party with respect to

contracting AC power transfer. In certain further embodiments, the agent may be a software agent executing on a software agent computer.

Figure **23** depicts a simplified system block of a computing system **2000** supporting contracting AC power transfer on an AC power network with a flow gate collection in accordance with certain embodiments.

Computing system **2000** is comprised of at least one computer **2020** coupled **2024** to computer readable memory **2026**. The communication and interaction between computing system **2000** and computer **2020** is denoted by arrow **2022**. Such communication and interaction **2022** may employ a variety of communications technologies, including a wireless physical transport layer in certain embodiments. In certain alternative embodiments, communication and interaction **2022** may employ a wireline physical transport layer.

Figure **24** depicts a refinement of computing system **2000** as a system diagram in Figure **23** in accordance with certain further embodiments. This computing system is comprised of a client computer collection and a server system **2500** coupled to a network **2200**.

The client computer collection is comprised of at least one client computer **2600** operated **2192** by client **2190**. In certain further embodiments, client computer **2610** operated **2104** by a human being as client **2100**. In certain other further embodiments, client computer **2620** operated **2124** by a corporate entity as client **2120**. In certain other further embodiments, client computer **2630** operated **2144** by an authorized agent as client **2140**. The first party is represented by an agent authorized by the first party to act on behalf of the first party with respect to contracting the AC power transfer.

Server system **2500** includes at least one server computer **2520** coupled to network **2200**. Network **2200** further couples **2602**, **2612**, **2622**, **2632** and **2642** to client computers **2600**, **2610**, **2620**, **2630** and **2640**, respectively. Network

2200 at least supports communication between client computers and at least one server computer **2520** of server system **2500**. As used herein, the term network refers not only to Local Area Networks (LANs), but also to Wide Area Networks (WANs). Network supported communication as used herein includes, but is not limited to, digital communication protocols as well as analog communication protocols. Network supported communication as used herein further includes, but is not limited to, message passing protocols and packet based protocols. Network supported communication as used herein further includes, but is not limited to, communication protocols including TCP/IP. Network supported communication as used herein further includes, but is not limited to, communication protocols supporting the Internet. Network supported communication as used herein further includes, but is not limited to, communication protocols supporting the World Wide Web.

In certain further embodiments, the client computer collection is comprised of at least one client computer **2600** with coupled **2604** computer readable memory **2606** operated **2192** by client **2190**. In certain further embodiments, client computer **2610** with coupled **2614** computer readable memory **2616** is operated **2104** by a human being as client **2100**. In certain other further embodiments, client computer **2620** with coupled **2624** computer readable memory **2626** operated **2124** by a corporate entity as client **2120**. In certain other further embodiments, client computer **2630** with coupled **2634** computer readable memory **2636** operated **2144** by an authorized agent as client **2140**.

In certain further embodiments, client computer **2610** with coupled **2614** computer readable memory **2616** operated **2104** by a client **2100** further coupled **2194** to computer readable memory **2606**. In certain further embodiments, client computer **2640** with coupled **2644** computer readable memory **2646** operated **2164** by a software agent as client **2160**. In certain other further embodiments, the coupling **2194** provides various personal optimizations and shortcuts,

including but not limited to macro style functions and standard contract forms employed by the client **2190**.

In certain other further embodiments, server system **2500** includes at least one server computer **2520** coupled **2524** to computer readable memory **2526**.

Figure **25A** depicts a detail flowchart of operation **1000** of Figure **3** performing identifying a first of the clients operating a first of the client computers as the first party.

Arrow **1410** directs the flow of execution from starting operation **1000** to operation **1412**. Operation **1412** performs identifying a first of the clients operating a first of the client computers as the first party. Arrow **1414** directs execution from operation **1412** to operation **1416**. Operation **1416** terminates the operations of this flowchart.

Figure **25B** depicts a flowchart of the first client user operating the first client computer as the first party.

Operation **1430** starts the operations of this flowchart. Arrow **1432** directs the flow of execution from operation **1430** to operation **1434**. Operation **1434** performs the first client user operating the first client computer as the first party. Arrow **1436** directs execution from operation **1434** to operation **1438**. Operation **1438** terminates the operations of this flowchart.

Figure **26** depicts a detail flowchart of operation **1434** of Figure **25B** performing operations related to first client stimulus, response and network communication with a first server computer of the server system.

Arrow **1450** directs the flow of execution from starting operation **1434** to operation **1452**. Operation **1452** performs receiving stimulus from the first user to create a received stimulus stream. Arrow **1454** directs execution from operation **1452** to operation **1456**. Operation **1456** performs communicating via

the network with the first server computer to create a received server stream and to create a server delivery stream. Arrow **1458** directs execution from operation **1456** to operation **1460**. Operation **1460** performs displaying a status based upon the received stimulus stream and the received server stream. Arrow **1462** directs execution from operation **1460** to operation **1464**. Operation **1464** terminates the operations of this flowchart.

Figure **27** depicts a detail flowchart of operation **1004** of Figure **3** performing communicating via the network with the first client computer to create a received server delivery stream.

Arrow **1490** directs the flow of execution from starting operation **1004** to operation **1492**. Operation **1492** performs communicating via the network with the first client computer to create a received server delivery stream. Arrow **1494** directs execution from operation **1492** to operation **1496**. Operation **1496** terminates the operations of this flowchart.

Figure **28** depicts a virtual trading floor **3000**, containing validated orders and market intervals with associated market states in accordance with certain embodiments.

A virtual trading floor mechanism **3000** comprises a collection of market intervals, each with an associated market state, and validated orders from certified clients. A market contains a product type and a location. Trading in the market is done in terms of market intervals **3100**, **3120**, **3140** and **3160**. Each market interval of a market contains the market product type, market location, plus a calendar scheme with an interval end. The market state of a market interval comprises a market price for the product type at the location during the calendar scheme with interval end.

Figure **29** depicts a detail flowchart of operation **1004** of Figure **3** performing supporting operating a virtual trading floor containing a market interval for trading AC power transfer for each of the flow gates of the flow gate collection.

Arrow **1510** directs the flow of execution from starting operation **1004** to operation **1512**. Operation **1512** performs operating a virtual trading floor containing a market interval for trading AC power transfer for each of the flow gates of the flow gate collection. Arrow **1514** directs execution from operation **1512** to operation **1516**. Operation **1516** performs operating a virtual trading floor at least one market interval for trading AC power transfer for each of the flow gates of the flow gate collection. Arrow **1518** directs execution from operation **1516** to operation **1520**. Operation **1520** terminates the operations of this flowchart.

Note that in certain further embodiments, a virtual trading floor may support contracting of AC energy in an AC power network as markets. In certain further embodiments, an ancillary energy service may be supported as a market. Ancillary energy services are typically defined within a regulatory region, such as an RTO (Regional Transmission Organization). By way of example, in California, such ancillary services provide AC power network operators with energy and transmission reserves to effect real-time balancing of the AC power network, and possibly the grid the AC power network belongs to. These networks may be controlled and maintained to remain within its operational parameters, such as voltage, frequency, phase stability and maximum safe carrying capacity. Examples of such ancillary markets in California include Spinning reserve, Non-spinning reserve, Black Start and Replacement Reserve.

Such ancillary services are treated as markets with an additional primary parameter. When contracting for ancillary energy services, operators pay for the right to call on an amount of power(energy), as well as pay for the energy at the agreed price. The facility reserves the power output of the ancillary service contract based upon the agreed fees paid for right to call on that power output.

The facility then generates a portion or all of that power output, at the operator's direction, based upon the agreed fee for that power production. Such a scheme may be applied to not only power generation but also to power transmission.

In certain further embodiments, a virtual trading floor may support contracting AC power and AC energy transfer in a grid containing at least one AC power network. In certain further embodiments, a virtual trading floor may support contracting of a DC power transfer within a grid as a market. Note that in certain embodiments, a grid may include at least two AC power networks.

Figure **30** depicts a detail flowchart of operation **1512** of Figure **29** performing collecting orders and creating contracts in accordance with certain embodiments.

Arrow **1530** directs the flow of execution from starting operation **1512** to operation **1532**. Operation **1532** performs transforming the received server delivery stream into an order collection containing at least one bid order and at least one ask order. Arrow **1534** directs execution from operation **1532** to operation **1536**. Operation **1536** performs contracting AC power transfer on the AC power network to create an agreed contract based upon a first of the bid orders of the order collection and based upon a first of the ask orders of the order collection. Arrow **1538** directs execution from operation **1536** to operation **1540**. Operation **1540** terminates the operations of this flowchart.

Consider an AC power network with a flow gate collection containing at least one flow gate. In certain embodiments, a virtual trading floor involving markets for the AC power network comprising, for each flow gate of the flow gate collection, a market trading AC energy transfer at a location corresponding to the flow gate. In certain further embodiments, there is at least one active market interval associated with each flow gate of the flow gate collection, where the location is the flow gate location in the AC power network and the product type is AC power transfer. Note that in certain embodiments, the AC power transfer product type

may have a diffe[illegible] designation, but be based upo[illegible]he same physical phenomena for AC power networks.

Validated orders from certified clients comprise bid orders for a specific market interval and ask orders of a specific market interval. A validated order in certain further embodiments may comprise multiple validated orders. A validated order in certain further embodiments may comprise multiple validated orders for a specific location and specific product. The bid and ask orders for a given market interval determine at least in part its market price.

In certain embodiments, each of the validated orders of the validated order collection belongs to a collection comprising a bid type and an ask type. In certain further embodiments, validated orders form an agreed contract with a bid order essentially matching an ask order in price for the same market interval. Validate orders are active only within a specified window on a calendar line. When real time passes the window of a market interval, the orders are rejected. Once agreed, orders are legally binding contracts between the contracting parties of the virtual trading floor for that market interval and can be used to generate commands to cause the product type transaction to occur at the specified location and for the calendar scheme of the closed market interval.

Figure **31** depicts a detail flowchart of operation **1004** of Figure **3** contracting AC power transfer based upon a first bid type order of the validated orders of the validated order collection and a first ask type order of the validated orders of the validated order collection.

Arrow **1550** directs the flow of execution from starting operation **1004** to operation **1552**. Operation **1552** performs contracting the AC power transfer on the AC power network based upon a first bid type order of the validated orders of the validated order collection and a first ask type order of the validated orders of the validated order collection. Arrow **1554** directs execution from operation **1552** to operation **1556**. Operation **1556** terminates the operations of this flowchart.

Figure **32** depicts a detail flowchart of operation **1182** of Figure **12** performing contracting for the AC power transfer on the AC power network to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow gates of the flow gate collection based upon a first bid type order of the validated orders of the validated order collection and a first ask type order of the validated orders of the validated order collection.

Arrow **1570** directs the flow of execution from starting operation **1182** to operation **1572**. Operation **1572** performs contracting for the AC power transfer on the AC power network to create an agreed contract by a first party to own AC power transfer trading rights with associated AC power transfers on each of the flow gates of the flow gate collection based upon a first bid type order of the validated orders of the validated order collection and a first ask type order of the validated orders of the validated order collection. Arrow **1574** directs execution from operation **1572** to operation **1576**. Operation **1576** terminates the operations of this flowchart.

In certain embodiments, process groups are used to provide a redundant, fault tolerant computing mechanism. A process group comprises a collection of identical processes, which perform the same computation at essentially the same time and write the same output to mass storage. To an outside observer, the process group appears as a single entity, even though the actual computation is replicated on several physical computers, which may be far apart from each other. Individual processes within the process group may crash, or new processes may join, but to an outside observer the process group will appear intact. Further, since the output saved to mass storage by all process group members is identical, the process group can survive any individual mass storage failure.

Figure **33A** depicts a flowchart of operations as previously described which collectively are included in the process groups performed on the reliable server system in accordance with certain embodiments.

Arrow **1602** directs the flow of execution from starting operation **1600** to operation **1000**. Operation **1000** performs operations discussed regarding Figure **3**. Arrow **1606** directs execution from operation **1000** to operation **1608**. Operation **1608** terminates the operations of this flowchart.

Arrow **1610** directs the flow of execution from starting operation **1600** to operation **1080**. Operation **1080** performs operations discussed regarding Figure **7**. Arrow **1614** directs execution from operation **1080** to operation **1608**. Operation **1608** terminates the operations of this flowchart.

Arrow **1620** directs the flow of execution from starting operation **1600** to operation **1210**. Operation **1210** performs operations discussed regarding Figure 13. Arrow **1624** directs execution from operation **1210** to operation **1608**. Operation **1608** terminates the operations of this flowchart.

Arrow **1630** directs the flow of execution from starting operation **1600** to operation **1310**. Operation **1310** performs operations discussed regarding Figure **18**. Arrow **1634** directs execution from operation **1310** to operation **1608**. Operation **1608** terminates the operations of this flowchart.

Figure **33B** depicts a method of controlling the interaction between a client **2190** and a virtual trading floor comprising maintaining a session component **3300**, participant component **3320** and market segment **3340** in accordance with certain embodiments.

In certain further embodiments, maintaining the session component **3300** comprises the following: Receiving an order request message **3302** from client **2190**. Sending the received order request message **3322** to the participant component **3320** to create a forwarded order request message for the participant

component. Receiving **3324** the acknowledgement message based upon the validated order request message and the relevant client list message for the validated order request message. Processing the received acknowledgement message and relevant client list for the validated order request message to create a broadcast update message for the validated order request message. Sending the broadcast update message **3304** to each of the clients **2190** of the relevant client list.

In certain further embodiments, maintaining the participant component **3320** comprises the following: Receiving the forwarded order request message **3302** from the session component. Maintaining **3332** a participant database **3330**. Validating the received, forwarded order request message. And responding to the validated order request message whenever the received, forwarded order request message is validated.

In certain further embodiments, maintaining the participant database comprises the following: Adding the received, forwarded order request message **3332** to the participant database **3330**. Validating the received, forwarded ordered request message requires examining **3324** and **3322** the session database based upon the received, forwarded order request message to create a validated order request message.

In certain further embodiments, responding to a validated message comprises the participant component performing the following activities: Sending an acknowledgement message **3324** based upon the validated order request message to the session component **3300**. Assembling a list of relevant clients for the validated order request message and sending **3324** the session component **3300** a relevant client list message for the validated order request message. Sending a market order request message **3342** to the market segment **3340** based upon the validated order request message.

In certain further embodiments, maintaining the market segment **3340** comprises performing the following activities: Receiving the market order request message **3342**. Maintaining **3352** a market segment database **3350** comprised of market intervals with associated market states as either active or closed. The market state of an active market interval comprises the total pending buy-position and the total pending sell-position.

In certain further embodiments, maintaining the market segment database **3350** comprises performing the following activities: Updating the market state of at least one market interval **3352** based upon the received market order request message **3342**. Reconciling the total pending buy-position with the total pending sell-position of at least one market interval. Closing a market interval.

In certain further embodiments, a virtual trading mechanism database comprising a read-only database **3360** for market configuration and for participant configuration by the virtual trading mechanism. In certain embodiments, settlement and schedule databases are not directly accessed by the virtual trading mechanism.

Figure **33C** depicts a refinement of computing system **2000** as a system diagram in Figure **24** in accordance with certain further embodiments. This computing system is comprised of a client computer collection and a server system **2500** coupled to a network **2200**.

As shown in Figure **24**, the client computer collection contains at least one client computer **2600** operated **2192** by client **2190**. In certain further embodiments, client computer **2610** is operated **2104** by a human being as client **2100**. In certain other further embodiments, client computer **2620** is operated **2124** by a corporate entity as client **2120**. In certain other further embodiments, client computer **2630** is operated **2144** by an authorized agent as client **2140**. The first party is represented by an agent authorized by the first party to act on behalf of the first party with respect to contracting the AC power transfer.

As shown in Figure 24, server system **2500** includes a server computer **2520** coupled **2528** to network **2200**. In certain further embodiments, server system **2500** includes server computer **2530** coupled **2538** to network **2200**. In certain further embodiments, server system **2500** includes server computer **2540** coupled **2548** to network **2200**. In certain further embodiments, server system **2500** includes server computer **2550** coupled **2558** to network **2200**. Note that in other further embodiments, even more server computers may be coupled to the network.

As shown in Figure **24**, network **2200** further couples **2602**, **2612**, **2622**, **2632** and **2642** to client computers **2600**, **2610**, **2620**, **2630** and **2640**, respectively. Network **2200** at least supports communication between client computers and at least one server computer **2520** of server system **2500**. As used herein, the term network refers not only to Local Area Networks (LANs), but also to Wide Area Networks (WANs). Network supported communication as used herein includes, but is not limited to, digital communications protocols as well as analog communication protocols. Network supported communication as used herein further includes, but is not limited to, message passing protocols and packet based protocols. Network supported communication as used herein further includes, but is not limited to, communication protocols including TCP/IP. Network supported communication as used herein further includes, but is not limited to, communication protocols supporting the Internet. Network supported communication as used herein further includes, but is not limited to, communications protocols supporting the World Wide Web.

As shown in Figure 24, in certain further embodiments, the client computer collection is comprised of at least one client computer **2600** with coupled **2604** computer readable memory **2606** is operated **2192** by client **2190**. In certain further embodiments, client computer **2610** with coupled **2614** computer readable memory **2616** is operated **2104** by a human being as client **2100**. In certain other further embodiments, client computer **2620** with coupled **2624**

computer readable memory **2626** is operated **2124** by a corporate entity as client **2120**. In certain other further embodiments, client computer **2630** with coupled **2634** computer readable memory **2636** is operated **2144** by an authorized agent as client **2140**.

As shown in Figure 24, in certain further embodiments, client computer **2610** with coupled **2614** computer readable memory **2616** is operated **2104** by a client **2100** further coupled **2194** to computer readable memory **2606**. In certain further embodiments, client computer **2640** with coupled **2644** computer readable memory **2646** is operated **2164** by a software agent as client **2160**. In certain other further embodiments, the coupling **2194** provides various personal optimizations and shortcuts, including but not limited to macro style functions and standard contract forms employed by the client **2190**.

As shown in Figure **24**, in certain other further embodiments, server system **2500** includes at least one server computer **2520** coupled **2524** to computer readable memory **2526**. Additionally, in certain further embodiments, server system **2500** includes server computer **2530** coupled **2534** to computer readable memory **2536**. Additionally, in certain further embodiments, server system **2500** includes server computer **2540** coupled **2544** to computer readable memory **2546**. Additionally, in certain further embodiments, server system **2500** includes server computer **2550** coupled **2554** to computer readable memory **2556**.

Note that in certain further embodiments, server computer coupled computer readable memory may contain a read-write accessible memory. Note that in certain further embodiments, the read-write accessible memory may contain at least one mass storage unit. In certain further embodiments, a mass storage unit may include a disk drive. In certain embodiments, a mass storage unit may be accessed using a file management system. In certain embodiments, a mass storage unit may be accessed as a database.

Certain embodiments include a method of operating a client computer with a client computer message address interfaced with a reliable distributed system composed of a server system containing server computers with associated messaging addresses. The method includes a login procedure, a message composition procedure for an outgoing message to the reliable distributed system, and a message analysis procedure for an incoming message from the reliable distributed system.

In certain further embodiments, the login procedure maintains a list of messaging addresses of the collection of computers of the distributed system, a first login message and a login protocol and performs the following:

a. A first server computer of the server system is selected, and a first login message is sent to the associated address of the first server computer.

b. If there is a first acknowledgement message received from the first server computer message address then the login procedure proceeds to perform the login protocol.

c. Whenever the login protocol fails with the first server computer or
   - whenever there is no acknowledgement message received from the first server computer within a predetermined amount of time or
   - whenever there remain server computers in the server system for which login has not been attempted,
   - the first server computer is selected from the remaining server computers of the server system and these steps are repeated.

d. Whenever the login protocol succeeds with the first server computer, the first server computer is designated the connection computer.

In certain further embodiments, the message composition procedure for an outgoing message to the distributed system comprises performing the following: Maintaining a list of message formats. Determining the selection of a first message format. Using the first message format to create an outbound message. Sending the outbound message to the connection computer.

In certain further embodiments, the message analysis procedure for an incoming message from the distributed system comprises performing the following: Receiving the message from the connection computer. Validating the received message creates a valid received message.

Certain embodiments employ an object class structure supporting message passing, each message comprises a message type and at least one message field. Each message-passing object comprises handling an unknown message type and handling for an unknown message field.

In certain further embodiments, handling an unknown message type for a received message from a first object by a second object comprises the first object sending the second object a reply message indicating unknown received message type and referencing the received message.

In certain further embodiments, handling an unknown message field of the received message by the second object comprises handling the other fields of the received message by the second object.

Certain embodiments employ a method of operating a reliable distributed system of a collection containing at least one process group running on several computers comprising receiving confirmed messages from certified clients and maintaining a group state. Each process group computer possesses a messaging address. The computers of a process group communicate amongst themselves with a virtually synchronous messaging system.

In certain further embodiments, receiving a confirmed message from a certified client occurs at one computer of the first collection of computers running the process group. Upon receipt the receiving computer broadcasts the confirmed message from the certified client to all computers of the first collection of computers.

In certain further embodiments, maintaining a group state at each computer of the first collection of computers of the process group comprising the following operations: Each computer processes the confirmed message from the certified client to create a group state candidate. Each computer broadcasting a virtually synchronous group state candidate message to the other computers. Each computer receives the virtually synchronous group state candidate messages of the other computers. Each computer analyzes the received virtually synchronous group state candidate messages and its own virtually synchronous group state candidate to create a new group state.

Certain embodiments employ a messaging system for message passing concurrent objects, instances of which reside on computers each possessing a controller belonging to a collection of computers comprising ABCAST protocol and GBCAST protocol. The ABCAST protocol is an atomic broadcast protocol used to communicate messages between object instances across the computers of the collection of computers. The GBCAST protocol is a global broadcast protocol to communicate messages between controllers of the computers of the collection of computers.

Certain embodiments employ an object class structure executing in a process group of computers communicating with each other via a messaging protocol supporting at least virtual synchrony. Each instance of each object of the object class structure comprises an object instance clone reading on each of the process group computers.

In certain further embodiments, each object instance may send and receive messages from other object instances and each object instance clone communicates with messages to other object instance clones of the same object instance.

In certain further embodiments, each object class possesses a state, which is member of a collection of states. Each instance of each object class state

changes as an atomic event. All activities of each object class occur as atomic events. Atomic events may be triggered by message reception. State changes in an object instance clone trigger transmission of a state change message to other object instance clones of the same object instance.

In certain embodiments, a concurrent computing entity resides on each of the computers of a process group of computers where it owns access to a binary file used for storing the resilient object instance state. It executes updates to the binary file as a transaction. The storage in the binary file is organized into table objects. Each table object consists of a set of records.

Figure **34** depicts a view of a certified client user interface operating on a client computer showing an ordering screen with hourly time interval based market intervals for a specific energy market in accordance with certain embodiments.

Figure **35** depicts a view of a certified client user interface operating on a client computer showing an ordering screen for daily on-peak time interval based market intervals for a specific energy market in accordance with certain embodiments.

Figure **36** depicts a view of a certified client user interface operating on a client computer showing an ordering screen for hourly time interval based market intervals for a specific flow gate market in accordance with certain embodiments.

The displayed information **4200** includes a variety of fields, including field **4202**, where a specific flow gate or intertie may be selected. Immediately below that field is a field which specifies commodity type, in this case, "Hourly Flowgate". The column indicated by **4204** represents the current market price. The column to its right indicates the amount of the commodity which has been awarded. The box **4206** points to two columnar components. The left component represents the auction bid quantity and the right component represents the bid price per unit quantity on each row. Note that each row represents a distinct market interval, trading independently of the other market intervals.

The preceding embodiments have been provided by way of example and are not meant to constrain the scope of the following claims.